Indicator: Blood Mercury Level and Childhood Blood Mercury (100 and 106)

Mercury is a naturally occurring metal that is widespread and persistent in the environment. It is found in elemental form and in various organic compounds and complexes. Methylmercury (an organic form) can accumulate in the food chain in aquatic systems and lead to high concentrations in predatory fish. Consumption of contaminated fish is the major source of human exposure to methylmercury in the United States (NRC, 2000).

The human health effects of mercury are diverse and depend on the forms of mercury encountered and the severity and length of exposure. Fetuses and children may be more susceptible to mercury than adults, with concern for the occurrence of developmental and neurological health effects (NRC, 2000). Prenatal exposures interfere with the growth and migration of neurons and have the potential to cause irreversible damage to the developing central nervous system. Blood mercury levels below 5.8 µg/L (the EPA Reference dose) are assumed to be without appreciable harm (CDC, 2004).

This indicator quantifies the blood mercury levels (includes organic and inorganic) among U.S. women aged 16–49 years and children aged 1–5 years, using data from the 1999-2002 National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. These data are presented here as a baseline with the intent of reporting trends in the future.

What the Data Show

For 1999–2002, the overall geometric mean for total blood mercury levels among women aged 16–49 years was 0.92 µg/L and among children aged 1–5 years it was 0.33 µg/L (Table 100_106Mercury). When the means are stratified across three racial/ethnic groups, Black, non-Hispanic women aged 16–49 have the highest levels (1.18 µg/L), followed by White, non-Hispanics (0.87 µg/L) and Mexican Americans (0.74 µg/L) Among children, Black, non-Hispanics have the highest geometric mean (0.50 µg/L), followed by Mexican Americans (0.35 µg/L) and White, non-Hispanics (0.29 µg/L) (CDC, 2004).

The percentage of women aged 16–49 years with blood mercury levels greater than or equal to 5.8 µg/L was 5.7% for 1999-2002 (CDC, 2004). White, non-Hispanic women (5.8%) were most likely to have levels above the Reference dose followed by Black, non-Hispanics (4.8%) and Mexican Americans (1.7%). Because so few children had levels ≥ 5.8 µg/L, a statistically reliable percentage could not be calculated.

Indicator Limitations

- NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 4 years of data in NHANES 1999-2000 and 2001-2002, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage.

    - The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2002 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description

below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses.

- For NHANES 1999-2000 and 2001-2002, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 and 2001-2002 NHANES samples are selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates.

- NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999, 2000, 2001, and 2002, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported.

- The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.

- The National Center for Health Statistics advises users of these data that the most reliable estimates of current exposure are obtained when the 1999–2002 data are analyzed together

- The measurement of mercury or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Data Sources

Centers for Disease Control and Prevention. 2004. Blood Mercury Levels in Young Children and Childbearing-Aged Women – United States, 1999-2002. MMWR 53:1018-1020 (Last Accessed December 2, 2004) http://www.cdc.gov/mmwr/PDF/wk/mm5343.pdf

References

Centers for Disease Control and Prevention (CDC). 2004. Blood Mercury Levels in Young Children and Childbearing-Aged Women – United States, 1999-2002. MMWR 53:1018-1020 (Last Accessed December 2, 2004) http://www.cdc.gov/mmwr/PDF/wk/mm5343.pdf

National Research Council (NRC). 2000. Toxicological Effects of Methylmercury. Washington, DC: National Academies Press.

Graphics

Table 100_106Mercury. Geometric mean and selected percentiles of blood mercury concentrations (in µg/L) for women aged 16 to 49 years and children (males and females) aged 1-5 years in the United States population, National Health and Nutrition Examination Survey (NHANES), 1999-2002

	Sample Size	Geometric Mean	10th	25th	50th	75th	90th
Women aged 16-49 years	3,637	0.92	0.17	0.40	0.86	1.81	3.89
Race Ethnicity							
Black, non-Hispanic	794	1.18	0.30	0.60	1.15	2.12	3.89
Mexican American	1,106	0.74	0.17	0.34	0.73	1.27	2.38
White, non-Hispanic	1,377	0.87	0.15	0.37	0.81	1.69	3.73
Children Aged 1-5 years	1,577	0.33	0.07	0.10	0.26	0.61	1.29
Race Ethnicity							
Black, non-Hispanic	424	0.50	0.10	0.22	0.47	0.88	1.54
Mexican American	526	0.35	0.08	0.13	0.28	0.63	1.36
White, non-Hispanic	447	0.29	0.07	0.09	0.20	0.49	1.15

Source: Centers for Disease Control and Prevention. 2004. Blood Mercury Levels in Young Children and Childbearing-Aged Women – United States, 1999-2002. MMWR 53:1018-1020. November 5, 2004. http://www.cdc.gov/mmwr/PDF/wk/mm5343.pdf

R.O.E. Indicator QA/QC

Data Set Name: BLOOD MERCURY LEVEL
Indicator Number: 100 (89096)
Data Set Source: CDC - NHANES
Data Collection Date: ongoing
Data Collection Frequency: 2 year cycles
Data Set Description: Blood Mercury Level (including childhood blood mercury - combines 100 & 106)
Primary ROE Question: What are the trends in biomeasures of exposure to common environmental pollutants including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Blood samples were collected and processed in accordance with the methods indicated in the NHANES Specimen Collection and Laboratory/Medical Technologists Procedures Manual (LPM). See: http://www.cdc.gov/nchs/data/nhanes/blood.pdf http://www.cdc.gov/nchs/data/nhanes/LAB1-6.pdf Total mercury in whole blood was measured by flow injection cold vapor atomic absorption analysis with on-line microwave digestion, based on the method by T. Buo and J. Bassner. Decomposition of organic mercury compounds in blood occurs mainly while the sample (mixed with bromate-bromide reagent and hydrochloric acid) flows through the digestion coil in the microwave. Further decomposition of organic mercury is achieved by on-line addition of potassium permanganate. The total (organic + inorganic) mercuric mercury released is reduced to mercury vapor by sodium tetrahydroborate. The mercury vapor is measured by the spectrometer at 253.7 nm. Inorganic mercury in whole blood is measured by using stannous chloride as reductant without employing microwave digestion system. Mercury vapor (reduced from inorganic mercury compounds) is measured via the same quartz cell at 253.7 nm. The difference in the total reduced mercury (by sodium tetrahydroborate) and inorganic reduced mercury (by stannous chloride) is taken to represent organic mercury in whole blood. See: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf The units used for this indicator were ¼g/L. http://www.cdc.gov/nchs/data/nhanes/frequency/varlab.pdf

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NHANES is designed to provide statistically representative national averages. Starting with NHANES 1999, the survey is conducted annually. Blood mercury levels were measured in a subsample of participants in NHANES 1999-2002 aged 1-5 years and in females aged 16-49 years. Subsamples were randomly selected within the specified age ranges to be a representative sample of the U.S. population. The measurement of total blood mercury included both the inorganic and organic forms.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on a national probability-based sampling design and is deemed of sufficient quality for generalization to the nation. The samples for 1999-2002 were used for this analysis. Quality assurance measures were in place. Beginning in 1999, NHANES became a continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population. Every year, approximately 7,000 individuals, of all ages, are interviewed in their homes; of these, approximately 5,000 complete the health examination component of the survey. The survey sample size for NHANES 1999-2000 is 9,965 (http://www.cdc.gov/nchs/data/nhanes/gendoc.pdf).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The current sampling design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 year olds), older Americans (60 years of age and older), and pregnant women to produce more reliable estimates for these groups.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply provides information that exposure to mercury has occurred. The American Conference of Governmental Industrial Hygienists recommends that the blood inorganic mercury of workers not exceed 15 ¼g/L. As reported in "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003 (http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf), the measurement of mercury or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Source: Centers for Disease Control and Prevention. 2004. Blood Mercury Levels in Young Children and Childbearing-Aged Women United States, 1999-2002. MMWR 53:1018-1020 (Accessed December 2, 2004) http://www.cdc.gov/mmwr/PDF/wk/mm5343.pdf Additional Documentation can be found on CDC's NHANES website. For instance: Documentation for NHANES 1999-2000 is found on NCHS/CDC website at the following URL: http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files The following provides more specific examples: The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures. http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf The Second National Report on Human Exposure to Environmental Chemicals published by the National Center for Environmental Health in 2003 more generally describes the NHANES 1999-2000 sampling plan. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf Laboratory measurement information: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf The NHANES 1999-2000 subsampling webpage clearly describes the subsampling methods used and how subsampled data should be analyzed http://www.cdc.gov/nchs/about/major/nhanes/subsample.htm as do the Weighting Notes posted on the NHANES website http://www.cdc.gov/nchs/data/nhanes/frequency/weights%20to%20usev6.pdf

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

For the most part, Individual level data are available, but data access limitations do exist for some variables due to confidentiality issues.
http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Addendum to the NHANES III for the 1999-2002 dataset clearly outlines the 1999-2002 sampling design and recommends analytic procedures.
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf
http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality assurance plans for NHANES 1999-2002 are available from the Division of Data Dissemination, NCHS, 6525 Belcrest Rd. Hyattsville, MD, 20782-2003. Tel. 301-458-4636. Internet: http://www.cdc.gov/nchs/about/quality.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The NHANES 1999-2002 survey is designed to be annually nationally representative of the U.S. citizen, non-institutionalized population. (see page 11 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. (see pages 11-19 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 4 years of data in NHANES 1999-2000 and 2001-2002, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage. The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2002 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses. For

NHANES 1999-2000 and 2001-2002, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 and 2001-2002 NHANES samples are selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999, 2000, 2001, and 2002, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported. The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.
http://www.cdc.gov/nchs/about/major/nhanes/subsample.htm

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Although the annual NHANES is nationally representative, it is not possible to produce environmental exposure estimates by geographic region. Because the number of geographic sites sampled each year is small and because environmental exposure measures may vary geographically, national estimates based on one year of data may be highly variable. Caution is needed when comparing blood mercury data between 1999-2000 and 2001-2002. Each time period (1999-2000 and 2001-2002) represents only two years of data. Changes in estimates between the two time periods do not necessarily reflect a trend. At least two more years of data are needed (e.g., 2003-2004) to better evaluate possible trends (CDC, 2004). Blood mercury levels were measured in all women aged 16-49 years and children aged 1-5 years. The measurement of mercury or any other environmental chemical in a person s blood or urine does not by itself mean that the chemical has caused or will cause harmful effects. As subsequent years are added to this survey, estimates will become more stable. However, with the laboratory data, there is no guarantee that an environmental chemical will be measured from year to year.